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LISTS OF SPECIES

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Butterflies (Lepidoptera: Papilionoidea) of grassland areas in the Pampa biome, southern Brazil

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Abstract: The temperate and subtropical grassland ecosystems are among the most threatened ecosystems in the world due to habitat loss. This study aimed to make a list of butterfly species present in native grassland fields in the city of Santa Maria, southern Brazil. The sampling field effort was 225 h using entomological nets, from 2009 to 2011. In total, 117 species of butterflies were recorded, distributed in six families and 18 subfamilies. Nymphalidae was the richest family, with 56 species, while Lycaenidae was the least rich family, with six species. Twenty species constitute new records for Santa Maria; while six of those are new records for the Central Depression Region of Rio Grande do Sul. In the face of global and local threats, it is urgent to increase efforts to study the biology and ecology of the grassland communities in order to provide support to biological conservation.

Key words: conservation, Nymphalidae, richness, species inventory

INTRODUCTION

The temperate and subtropical grassland ecosystems are among the most threatened ecosystems in the world due to habitat loss, caused by the impact of human activities, and due to the small extent of protected areas (Hoekstra et al. 2005). In Brazil, these ecosystems are represented in the three southernmost states of the country, from Paraná to Rio Grande do Sul, where they occur in the Atlantic Forest and Pampa biomes (IBGE 2004; Boldrini 2009; Iganci et al. 2011). Even though the Pampa represents only 2% of the national territory, it occupies 63% of Rio Grande do Sul state (IBGE 2004), and it continues into Uruguay and part of Argentina, constituting the Pampa bioregion with an approximate total area of 750,000 square kilometers (Martino 2004). The fertile soils, flat topography, and the low density of trees facilitated the transformation of these ecosystems. Agricultural activities and the introduction of exotic species are the main threats to the local biodiversity (Martino 2004; Behling et al. 2009; Roesch et al. 2009; Medan et al. 2011).

In Rio Grande do Sul state, where the largest remains of preserved grasslands are still found, the floristic composition of these fields is fairly well known, and they are estimated to contain a richness of 2,200 species (Boldrini et al. 2010; Iganci et al. 2011). Apiaceae, Asteraceae, Cyperaceae, Fabaceae, Iridaceae, Oxalidaceae, Poaceae, and Verbenaceae are the most representative families of plants (Overbeck et al. 2007). Regarding the fauna, the grassland ecosystems are an important habitat for many taxonomic groups, and some studies have been published involving endemic and threatened vertebrate species (Bencke 2009; FZB/RS 2014; Lipinski and Santos 2014). However, there is still a lack of knowledge in relation to other taxonomic groups, including terrestrial invertebrates, whose functions can be related to herbivory, nutrient cycling, and pollination processes in terrestrial ecosystems, among others (Medan et al. 2011). Among the few published studies, we highlight some insect inventories that include butterflies, beetles and heteropterans (Marchiori and Romanowski 2006; Paz et al. 2008, 2014; Bunde et al. 2010; Rosa et al. 2011, Silva et al. 2012).

Although butterflies are considered a fairly well studied group in Rio Grande do Sul state (see revisions in Morais et al. 2007; Santos et al. 2008), a full list of butterfly species was only recently published (Giovenardi et al. 2013). According to their results, the records of the 832 species and subspecies (about a quarter of the 3,200 species listed in Brazil, recorded by Brown and Freitas 1999) are unevenly distributed in different physiographic regions. The research of Giovenardi et al. (2013) exposed the unequal number of studies and revealed gaps, mainly in certain areas of the Pampa biome. Additional studies on butterflies are also necessary because some groups are considered biological indicators due to their

close associations with the environment in which they live. Some species are very sensitive to environmental changes, and thus the butterflies found in a given location can report the conservation status of the area (Freitas et al. 2006; Bonebrake et al. 2010; Marini-Filho and Freitas 2011).

The Central Depression Region of Rio Grande do Sul is considered an area of ecological tension because it is located on the border between the Atlantic Forest and Pampa biomes (Cordeiro and Hasenack 2009). Along with the urbanization process, this region has undergone a substantial increase in anthropogenic pressure due to the expansion of cities and related activities such as agriculture, industry, and exotic silviculture (Robaina et al. 2001; Marchiori 2009; Paz et al. 2014). It is worth mentioning that the most threatened areas are those with grassland vegetation, which have traditionally been disregarded or considered of minor importance in relation to biodiversity (Overbeck et al. 2007). Considering that the previous butterfly studies in the region were mainly performed in forest fragments or urban areas, this study aimed to make a list of butterfly species present in native grassland fields. Thus, we intend to provide knowledge to be used in the conservation of this faunal group and its associated, severely threatened habitats in southern Brazilian Pampa.

MATERIALS AND METHODS

The study was conducted at two sites located on the periphery of the city of Santa Maria, where the vegetation is a relatively preserved part of the original native landscape. The first site is situated in the Criadouro Conservacionista São Braz (CCSB) (29°41′56″ S, 053°54′59″ W), a private property located about 12 km from the municipal center. The second site is located in the Centro de Instrução de Santa Maria (CISM) (29°44′34″ S, 053°50′46″ W), a military property located about 7 km from downtown Santa Maria. Anthropogenic and agricultural activities exist at low levels in both sites.

The local climate is humid subtropical (Maluf 2000), with an annual mean temperature of 19.1°C and annual mean precipitation of 1,712.4 mm (Heldwein et al. 2009). The local vegetation is mostly composed of open grassland fields, along with small riparian forest fragments and waterways (Marchiori 2009). Regarding the taxonomic composition, there are tropical and subtropical vegetation species, with a strong presence of Fabaceae and Poaceae (Marchiori 2009; Boldrini et al. 2010).

The sampling field effort was 225 h using entomological nets, from 2009 to 2011. The nomenclature for the butterfly species was based on Lamas (2004) and subsequent revisions (Mielke 2005; Wahlberg et al. 2009; Heikkilä et al. 2012). The vouchers are deposited in the Reference Collection of the Laboratory of Insect-Plant Interactions, Departamento de Biologia, Centro de Ciências Naturais e Exatas from Universidade Federal de Santa Maria, Santa Maria, Rio Grande do Sul state, Brazil (SISBIO license number 20395).

The studies of Link et al. (1977, 1980); Schwartz and Di Mare (2001); Dessuy and Morais (2007); Sackis and Morais (2008); Lemes et al. (2008, 2015) and Spaniol and Morais (2015) have been consulted to confirm new records for Santa Maria.

RESULTS

In total, 117 species of butterflies were recorded (Table 1), distributed in six families and 18 subfamilies. Nymphalidae was the richest family, with 56 species, followed by Hesperiidae (26), Pieridae (11), Papilionidae (10), Riodinidae (8), and Lycaenidae (6).

Twenty species constitute new records for Santa Maria: six Nymphalidae, six Riodinidae, four Lycaenidae, three Hesperiidae, and one Pieridae (Table 1).

DISCUSSION

It is very important to consider that the knowledge of the Pampa biome animal biodiversity is still very incomplete (Medan et al. 2011). Moreover, the biology and ecology of grassland butterfly communities from this biome are still almost unknown due to the scarcity of standardized butterfly inventories. It is also very concerning that there are no studies being conducted in the Pampa domains of Uruguay and Argentina. As far as we know, the present study constitutes the first standardized inventory using the method of capture by entomological net performed exclusively in native Pampa biome grasslands.

The number of butterfly species recorded (S = 117) corresponds to about one-half of the estimated richness for Santa Maria (Cechin et al. 2009) and almost one-quarter of the total listed by Giovenardi et al. (2013) for the Central Depression Region. Although not comparable due to the different habitats and sampling efforts, the richness of grassland butterflies of Santa Maria was superior to the only other two entomological net standardized inventories performed in the Pampa biome: Espinilho Park (S = 97, Marchiori and Romanowski 2006) and Urban Park of Uruguaiana (S = 46, Rosa et al. 2011). Additionally, Paz et al. (2014) recorded 44 species of fruit feeding butterflies associated with grassland areas in the nearby central western region of the state after two years of sampling using bait traps.

The richness of the families in this study reflects their total numbers of species for the Neotropical region (Lamas 2008), considering that Nymphalidae and Hesperiidae are the most numerous. However, due to the fact that many adult butterflies of Hesperiidae are small and difficult to collect (Brown and Freitas 1999),

Table 1. Butterflies (Lepidoptera: Papilionoidea) recorded in two grassland areas in Santa Maria, Rio Grande do Sul state, Brazil, from 2009 to 2011. * Indicates first record in Santa Maria.

PAPILIONIDAE	*Eurema elathea flavescens* (Chavannes, 1850)	*Eryphanis reevesii* (Doubleday, [1849])
Papilioninae	*Eurema phiale paula* (Röber, 1909)	*Hermeuptychia atalanta* (Butler, 1867)
Battus polydamas polydamas (Linnaeus, 1758)	*Phoebis neocypris neocypris* (Hübner, [1823])	*Hermeuptychia gisella* (Hayward, 1957)
Euryades corethrus (Boisduval, 1836)	*Phoebis philea philea* (Linnaeus, 1763)	*Moneuptychia soter* (Butler, 1877)
Heraclides anchisiades capys (Hübner, [1809])	*Phoebis sennae marcellina* (Cramer, 1777)	*Morpho aega aega* (Hübner, [1822])
Heraclides astyalus astyalus (Godart, 1819)	*Rhabdodryas trite banksi* (Breyer, 1939)	*Morpho helenor achillides* C.Felder & R.Felder, 1867
Heraclides hectorides (Esper, 1794)	**Dismorphiinae**	**Opoptera aorsa aorsa* (Godart, [1824])
Heraclides thoas brasiliensis (Rothschild & Jordan, 1906)	*Pseudopieris nehemia* (Boisduval, 1836)	*Paryphthimoides phronius* (Godart, [1824])
Mimoides lysithous rurik (Eschscholtz, 1821)	**NYMPHALIDAE**	*Paryphthimoides poltys* (Prittwitz, 1865)
Parides agavus (Drury, 1782)	**Heliconiinae**	**Stegosatyrus periphas* (Godart, [1824])
Parides anchises nephalion (Godart, 1819)	*Actinote carycina* Jordan, 1913	*Taygetis ypthima* Hübner, [1821]
Parides bunichus perrhebus (Boisduval, 1836)	*Actinote melanisans* Oberthür, 1917	*Yphthimoides celmis* (Godart, [1824])
HESPERIIDAE	*Agraulis vanillae maculosa* (Stichel, [1908])	*Yphthimoides ordinaria* Freitas, Kaminski & Mielke, 2012
Hesperiinae	*Dione juno juno* (Cramer, 1779)	**Danainae**
Anthoptus epictetus (Fabricius, 1793)	*Dryas iulia alcionea* (Cramer, 1779)	*Danaus erippus* (Cramer, 1775)
Callimormus interpunctata (Plötz, 1884)	*Euptoieta claudia* (Cramer, 1775)	*Dircenna dero* (Hübner, 1823)
Callimormus rivera (Plötz, 1882)	*Heliconius erato phyllis* (Fabricius, 1775)	*Episcada hymenaea hymenaea* (Prittwitz, 1865)
**Cobalopsis miaba* (Schaus, 1902)	*Heliconius ethilla narcaea* Godart, 1819	*Epityches eupompe* (Geyer, 1832)
**Euphyes cherra* Evans, 1955	**Philaethria wernickei* (Röber, 1906)	**Lycorea ilione ilione* (Cramer, 1775)
Nastra lurida (Herrich-Schäffer, 1869)	**Limenitidinae**	*Mechanitis lysimnia lysimnia* (Fabricius, 1793)
Polites vibex catilina (Plötz, 1886)	**Adelpha hyas* (Doyère, [1840])	*Methona themisto* (Hübner, 1818)
Pompeius amblyspila (Mabille, 1898)	*Adelpha mythra* (Godart, [1824])	*Pseudoscada erruca* (Hewitson, 1855)
Wallengrenia premnas (Wallengren, 1860)	*Adelpha syma* (Godart, [1824])	**Apaturinae**
Pyrginae	*Adelpha thessalia indefecta* Fruhstorfer, 1913	**Doxocopa kallina* (Staundiger, 1886)
**Achlyodes busirus rioja* Evans, 1953	**Nymphalinae**	*Doxocopa laurentia laurentia* (Godart, [1824])
Achlyodes mithridates thraso (Hübner, [1807])	*Anartia amathea roeselia* (Eschscholtz, 1821)	**RIODINIDAE**
Autochton zarex (Hübner, 1818)	*Eresia lansdorfi* (Godart, 1819)	**Riodininae**
Celaenorrhinus sp.	*Hypanartia bella* (Fabricius, 1793)	**Aricoris indistincta* (Lathy, 1932)
Gorgythion begga begga (Prittwitz, 1868)	*Junonia evarete* (Cramer, 1779)	**Caria marsyas* Godman, 1903
Gorgythion sp.	*Ortilia dicoma* (Hewitson, 1864)	**Emesis lupina melancholica* Stichel, 1916
Heliopetes arsalte (Linnaeus, 1758)	*Ortilia orthia* (Hewitson, 1864)	**Mesosemia odice* (Godart, 1824)
Heliopetes libra Evans, 1944	*Siproeta epaphus trayja* Hübner, [1823]	*Riodina lycisca lycisca* (Hewitson, [1853])
Heliopetes omrina (Butler, 1870)	*Siproeta stelenes meridionalis* (Fruhstorfer, 1909)	**Euselasiinae**
Milanion leucaspis (Mabille, 1878)	*Tegosa claudina* (Eschscholtz, 1821)	**Euselasia euploea* (Hewitson, [1855])
Pyrgus orcus (Stoll, 1780)	*Tegosa orobia* (Hewitson, 1864)	**Euselasia hygenius occulta* Stichel, 1919
Pyrgus orcynoides (Giacomelli, 1928)	*Vanessa braziliensis* (Moore, 1883)	*Euselasia satyroides* Lathy, 1926
Urbanus procne (Plötz, 1880)	**Charaxinae**	**LYCAENIDAE**
Urbanus proteus proteus (Linnaeus, 1758)	*Zaretis strigosus* (Gmelin, [1790])	**Theclinae**
Urbanus simplicius (Stoll, 1790)	**Biblidinae**	*Calycopis caulonia* (Hewitson, 1877)
Urbanus teleus (Hübner, 1821)	*Biblis hyperia nectanabis* (Fruhstorfer, 1909)	**Cyanophrys acaste* (Prittwitz, 1865)
Xenophanes tryxus (Stoll, 1780)	*Diaethria candrena candrena* (Godart, [1824])	**Pseudolycaena marsyas* (Linnaeus, 1758)
PIERIDAE	*Dynamine myrrhina* (Doubleday, 1849)	*Rekoa palegon* (Cramer, 1780)
Pierinae	*Eunica eburnea* Fruhstorfer, 1907	**Theritas triquetra* (Hewitson, 1865)
Ascia monuste orseis (Godart, 1819)	*Hamadryas amphinome amphinome* (Linnaeus, 1767)	**Polyommatinae**
**Hesperocharis paranensis* Schaus, 1898	*Hamadryas februa februa* (Hübner, [1823])	**Zizula cyna* (W. H. Edwards, 1881)
Coliadinae	**Satyrinae**	
Eurema albula sinoe (Godart,1819)	*Capronnieria galesus* (Godart, [1824])	
Eurema deva deva (Doubleday, 1847)	*Carminda paeon* (Godart, [1824])	

their richness might have been undersampled in the field sites. In contrast, the low richness of Lycaenidae and Riodinidae could be related to the gregarious behavior of some species of these families and reduced active period of the adults, resulting in either rareness or abundance in the field (DeVries 1997; Brown and Freitas 1999; Siewert et al. 2014).

Most of the new records for Santa Maria were for species previously reported from the Central Depression Region (Giovenardi et al. 2013) with the exceptions of the Riodinidae: *Aricoris indistincta* (Lathy, 1932), *Caria marsyas* Godman, 1903, *Emesis lupina melancholica* Stichel, 1916, and *Euselasia euploea* (Hewitson, [1855]). *Euselasia satyroides* Lathy, 1926 is a recently taxonomically reviewed species (Santos et al. 2014) that was referred to as *E. eugeon* (Giovenardi et al. 2013) and *Euselasia* sp. (Siewert et al. 2014 and Lemes et al. 2015), and thus our report of this species is not a new record. The Lycaenidae *Zizula cyna* (W. H. Edwards, 1881) is a small butterfly also recorded for the first time in this region.

Among the species that deserve attention, we highlight the presence of the Satyrinae *Stegosatyrus periphas* (Godart, [1824]) and *Opoptera aorsa aorsa* (Godart, [1824]), which were both recorded in this study only at CCSB. The first species is considered a biological indicator for preserved grassland areas and was previously recorded in other regions of southern Brazil (Morais et al. 2007; Dolibaina et al. 2011; Giovenardi et al. 2013; Zacca et al. 2013). *Opoptera aorsa aorsa* had only been previously recorded in the north and northwestern regions of Rio Grande do Sul state (Giovenardi et al. 2008, 2013). The adults of these butterflies have fruit feeding habits and their larvae use host plants of the Poaceae family (grasses) (Beccaloni et al. 2008), which are characteristic of grassland ecosystems. However, neither one of these two species was recorded in the 2-year inventory with bait traps performed in relatively nearby grassland fields of central western Rio Grande do Sul state (Paz et al. 2014).

As the biology and ecology of many South American butterfly species, especially from Pampa biome, remains fragmentary or unknown (Lamas 2008; Marini-Filho and Freitas 2011), it is not simple to design conservation programs and propose management plans without this basic knowledge. Among the species recorded here, some were already recognized as characteristic of southern Brazilian grassland fields, such as the Hesperiidae *Euphyes cherra* Evans, 1955 and *Polites vibex catilina* (Plötz, 1886), the Pieridae *Eurema phiale paula* (Röber, 1909), the Papilionidae *Euryades corethrus* (Boisduval, 1836), and the previously mentioned *S. periphas* (Dolibaina et al. 2011).

Euryades corethrus is a species included in both the Red List of Threatened Species of Paraná (Endangered) and of Rio Grande do Sul (Vulnerable) states (Dolibaina et al. 2010; FZB/RS 2014). Although the individuals of this species can be locally abundant, a revision of its status to critically endangered (CR) was proposed in Paraná (Dolibaina et al. 2010). The motives of this proposition in Paraná, primarily the potential for habitat losses, along with the absence of representative grassland conservation areas, also exist for the Pampa biome (Dolibaina et al. 2011; Medan et al. 2011).

The present study showed that the native grasslands of Santa Maria harbor a substantial butterfly fauna and future research will certainly increase the known species richness. In the face of global and local threats to temperate and subtropical grassland ecosystems, especially in the Pampa biome, it is urgent to increase efforts to study the biology and ecology of their communities in order to provide support for biological conservation and implementation of long-term policies. In the Pampa of southern Brazil, in particular, the small number of representative conservation units of grassland ecosystems may accelerate the extinction of many species before we can elucidate their ecological patterns and processes of occurrence and distribution. We recommend more investigative studies associated with environmental education campaigns in order to decelerate the conversion of habitats, therefore preserving the biodiversity value of the native grassland remnants.

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